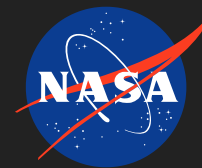


Synthetic Biology and Microbial Fuel Cells: Towards Self-Sustaining Life Support Systems

Completed Technology Project (2011 - 2012)



Project Introduction

NASA ARC and the J. Craig Venter Institute (JCVI) collaborated to investigate the development of advanced microbial fuels cells (MFCs) for biological wastewater treatment and electricity production (electrogenesis). Synthetic biology techniques and integrated hardware advances were investigated to increase system efficiency/robustness, with the intent of increasing power self-sufficiency and potential product formation from carbon dioxide. MFCs possess numerous advantages for space missions, including rapid processing, reduced biomass and effective removal of organics, nitrogen and phosphorus. Project efforts include developing space-based MFC concepts, integration analyses, increasing energy efficiency, and investigating novel bioelectrochemical system applications.

Innovative strategies are needed to overcome current limitations of wastewater treatment systems in space, while maximizing resource recovery (e.g., energy, water, CO₂) and providing substantial cost savings. JCVI is developing MFC technologies that rapidly and efficiently treat high-organic wastewaters with simultaneous electricity generation. This approach employs fixed-film microbial communities as biocatalysts to efficiently oxidize organic compounds into electrons, protons and carbon dioxide. The electrons are biologically transferred to a conductive anode electrode and flow across the MFC circuit, generating a modest electric current. The reduction reactions occur at the MFC cathode electrode using a biotic or abiotic catalyst to reduce electrons, protons, and air to actually produce new (pure) water. This strategy accelerates treatment, decreases secondary sludge biomass, reduces waste gases from anaerobic digestion of solid material, controls unwanted fixed films by accelerated energy removal from biological components and does not necessitate solid and liquid waste separation. MFCs may also treat select "problem" compounds not captured by membrane-based technologies, thereby enabling a new class of water processing systems that significantly increase reliability and savings over current technologies.

Anticipated Benefits

This project is a preliminary collaborative examination of the use of novel microbial fuel cell systems for space applications, and is an initial effort supporting the NASA ARC Synthetic Biology Initiative. Potential benefits to space exploration include providing wastewater treatment capabilities without incurring an oxygen utilization penalty, reduced power utilization and the potential to produce other mission-relevant products from the carbon dioxide generated in the anode compartment. It is anticipated that this technology would be best suited to long-duration missions, including lunar and planetary base operations.

Because of its ability to both treat wastes and generate products from that waste, this work includes foundational aspects that would yield widespread terrestrial commercial and military utilization. US government agencies that



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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

Center Innovation Fund: ARC CIF

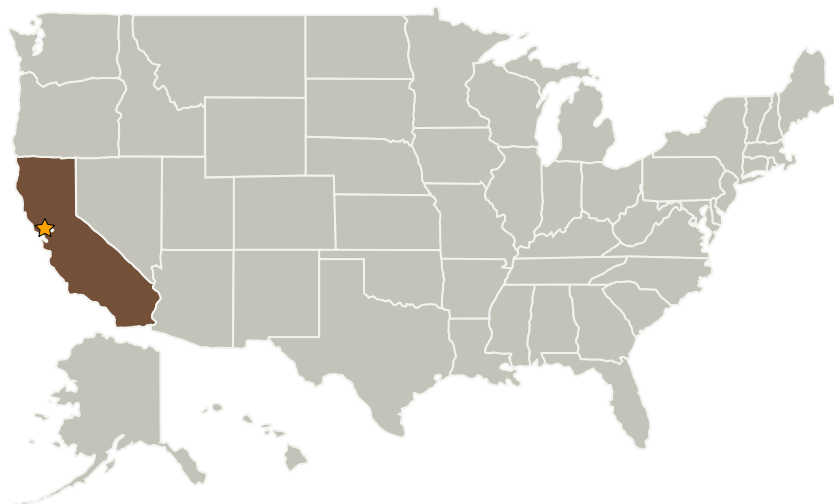
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could potentially apply this system include the Department of Energy's ARPA-E Program as well as the Department of Defense.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
J. Craig Venter Institute, Inc.	Supporting Organization	Industry	La Jolla, California

Primary U.S. Work Locations

California

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Harry Partridge

Project Manager:

John A Hogan

Principal Investigator:

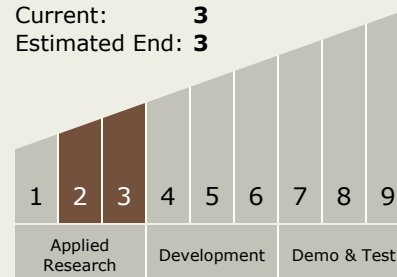
John A Hogan

Co-Investigator:

Michael Flynn

Technology Maturity (TRL)

Start: 2
Current: 3
Estimated End: 3



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
 - TX06.1 Environmental Control & Life Support Systems (ECLSS) and Habitation Systems

Continued on following page.

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Technology Areas (cont.)

- └ TX06.1.5 ECLSS
Modeling and
Simulation Tools